OBSERVATION OF LIGHTNING-INDUCED SIGNALS ON THE SUMMIT OF LA GRANDE MONTAGNE: PART 2 – INTERFEROMETRY AND VLF MEASUREMENTS

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Article available at http://www.e3s-conferences.org
VLF INSTRUMENTATION

Two perpendicular magnetic loops and an electric spherical sensor connected to a ground-based version of the ELMAVAN analyzer (RESONANCE spacecraft mission) [200 Hz – 20 kHz]

La Grande Montagne
(1028 m, 43.9410N, 5.4836E)

8/2012 – 9/7/2013
VLF OBSERVATION OF DISTANT LIGHTNING
VLF OBSERVATION OF DISTANT LIGHTNING
VLF OBSERVATION OF CLOSE LIGHTNING

last record

[Graph showing VLF observations]
PRE-STROKE PULSE ACTIVITY

1. RS
PRE-STROKE PULSE SEQUENCE IN THE VLF RANGE

![Graph showing electric field E and magnetic fields B (W-E) and B (N-S) over time.](image)
BROADBAND HF INTERFEROMETRY


We use a system of two perpendicular SLAVIA sensors (Shielded Loop Antenna with a Versatile Integrated Amplifier) to detect horizontal components of the magnetic field fluctuations in a frequency interval from 5 kHz to 90 MHz.

The direction to sources of broadband radiation is derived from a combination of the amplitude ratio and time delay of signals arriving at the two sensors placed at a distance of 89m.
Initial configuration

Two perp antennas
29.4 m baseline
3-26 September 2013

-25 deg
29.4 m
+6 deg

SLAT1

SLAT2

-25 deg
+6 deg

25 deg

N

+ scale2

+ dB/db > 0

+ dB/db > 0

+ scale1

+ 50 ft

+ 20 m
INTERFEROMETRY: SLAVIA 1 (black) - SLAVIA 2 (red, lagged and scaled), Baseline = 29.4m, Azim$_{1,2}$ = -25°, Scale$_2$ = 3.47, Lag$_2$

SLAVIA 1 loop plane azimuth = 65 degrees, SLAVIA 2 loop plane azimuth = -25 degrees, File=20130902_180501d.bin, Time accuracy = 45330 us, T1 = +52.0°C, T2 = +110.5°C, Voltage = 0V, Gain = 41dB.

- Interferometry data [mT/s]
- Integrated data [nT]
- Calibrated data [mT/s]

Time (ns) from 2013-09-02T18:05:06.864.273.408 to Trigger at 48 ns; SLAVIA1: outside -9.38 and 9.38 mT/s; SLAVIA2:...
Actual configuration

Since 26 September 2013

Two perp antennas

89m baseline

$\theta_1 = 89^\circ$

$\theta_2 = -17^\circ$

$\gamma = 25^\circ$

dB/dt > 0
Broadband electromagnetic measurement of lightning discharges

Live online data recorded by the Institute of Atmospheric Physics, Prague, Czech Republic in collaboration with Laboratoire Souterrain a Bas-Bruit, Rustrel, France. The thunderstorm activity is continuously monitored in a favorable electromagnetic environment on the summit of La Grande Montagne (1028 m, 43.9410N, 5.4836E), Plateau d'Albion. These measurements are prepared as a ground-based counterpart of instrumentation which is being developed by the Institute of Atmospheric Physics for the TARANIS spacecraft.

The SLAVIA sensors (Shielded Loop Antenna with a Versatile Integrated Amplifier) detect horizontal components of magnetic field fluctuations in a frequency interval from 5 kHz to 90 MHz. The loop surface is 0.23 m², the maximum gain is 47 dB. The maximum sensitivity of the recording system is 6 nT/s/√Hz, corresponding to 1 fT/√Hz at 1 MHz.

1. Overview of four days of measurements (time is given in UTC):

2. Latest broadband waveform snapshot:
Radio Monte Carlo 216 kHz
longwave transmitter at
Roumoules 1.4 MW
CG+
111kA
22 km
+14 deg
SLAVIA 2 (loop azimuth -25°) 167 ms from 2013-11-08T20:57:35.212.845.056 after 771 secs TRIGGER

20131108_204443.bn, dt=0 us, T1=+44.0 C, T2=+36.0 C, U= 14.989 V, G=41dB, R=800mV, N=33553920 at 200.00MHz, bits=12, BLESK2013-11-22
CONCLUSIONS

Analysis of VLF and HF electromagnetic signals radiated by in-cloud discharges is a useful tool for looking inside the thundercloud.

The broadband interferometry method allows us to estimate the movement of irradiative sources of the pulses in the pulse sequences using a new antenna system.

The ground-based measurements will complete the satellite measurements after the launch of the TARANIS spacecraft.